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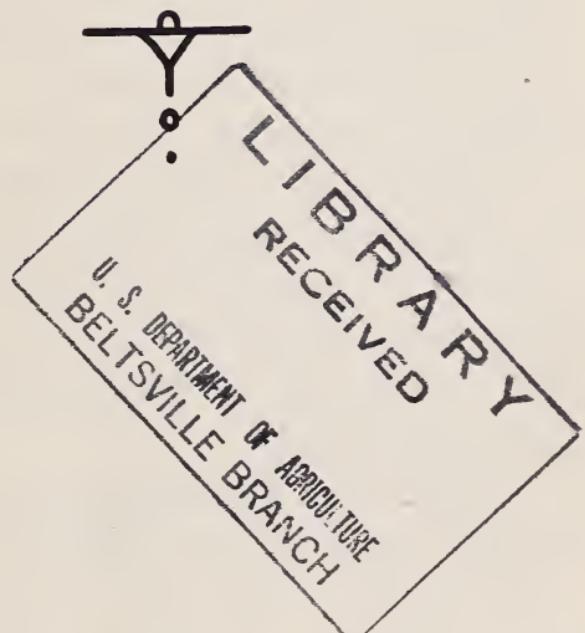


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# INSECT CONTROL in the COUNTRY WHEAT ELEVATOR



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THE country elevator operator must constantly be alert to see that he does not acquire infested wheat from the producer and that it does not become infested while it is in his possession.

### Origin of Insect Infestation

Insect infestation in wheat usually originates in storage, either on the farm or in the elevator. It is seldom infested in the field. In some sections of the country the angoumois grain moth flies to the field and lays its eggs on the developing wheat heads, so that a very small percentage of the kernels become infested. In areas where wheat is combined, field infestation by this insect is not important, since after the wheat is binned the few fragile moths that may develop are unable to force their way out of the grain to mate and lay more eggs.

The rice weevil may fly to the wheat fields, but it has difficulty in penetrating the husk covering the kernel to lay its eggs. A field infestation by this weevil is therefore of no importance. Many reports are received of wheat loads containing weevil-damaged kernels when they arrive at the elevator direct from the field. Such damage has been found to be caused by field insects, such as grasshoppers or the wheat head armyworm. The holes are made by insects feeding from the outside, not by weevils boring out.

## Infestation in Farm Storage

Wheat that is stored on the farm is sure to become infested unless the farmer takes great precautions to protect it. On many farms wooden bins are used to store wheat, and they have been used for many years. The walls and floors have become honeycombed by burrows of the cadelle, and thousands of insects find food and shelter there. Waste grain and feed in surrounding farm structures also harbor insects that crawl or fly to grain stored in the bins.

The elevator operator must inspect carefully all farm-stored wheat offered him for sale or storage. It is a temptation for some producers to get rid of old infested wheat by mixing it with newly harvested wheat. Needless to say, this practice ruins the entire load.

It is to the elevator operator's advantage to see that farmers in his vicinity know how to prevent infestations in their farm-stored grain. Farmers should--

1) Store only wheat that is dry, preferably with not more than 12 percent of moisture.

2) Store in weather-tight, rodent-proof bins, preferably of steel.

3) Clean out all bins before loading them with wheat. Spray walls and floors of wooden bins and around door frames of metal bins.

4) Clean up and dispose of litter, waste grain, and feed that has accumulated in and around farm buildings. Insects cannot live on premises that are clean.

5) Fumigate wheat in 2 to 4 weeks after placing it in storage.

6) Inspect wheat frequently and re-fumigate if an infestation is discovered.

### What Is Hidden Infestation?

Some insects spend a portion or all of their existence within the wheat kernels, where they may be out of sight. Such a hidden infestation is most troublesome to the miller, because it cannot be easily removed in the cleaning or milling process, and insect excrement and fragments contaminate the flour if infested grain is milled.

Grain standards do not take this hidden infestation into consideration, but in the future wheat stocks that are materially contaminated with this type of infestation will be relegated to animal feeds.

The insects that spend at least part of their lives within the kernels are the rice weevil, the granary weevil, the angoumois grain moth, the lesser grain borer, the flat grain beetle, the cadelle, and sometimes the sawtoothed grain beetle and the flour beetles.

### How Can the Elevator Operator Recognize Infested Wheat?

The elevator operator should not purchase wheat that contains free-living insects or a hidden infestation unless the wheat is to be used for feed. To determine whether free-living insects are present he should take probe samples. Sometimes he may see them crawling over the load. The presence of a few minor pests may not make the

wheat unfit for milling purposes, but a few weevils would be serious. If wheat containing a light infestation is purchased, it should be placed in a quarantine bin and fumigated immediately.

It is more difficult to detect a hidden infestation. Its presence may not be suspected, for the free-living forms may have been killed by fumigation or removed by screening. The Food and Drug Administration has recently discovered that one kernel with a weevil-emergence hole in a sample of wheat indicates that at least five kernels in the sample contain a hidden infestation. They suggest that a visual examination be made of a 100-gram sample (about 1/4 pint) of wheat, and that, if three kernels with emergence holes are found, the wheat be examined by the cracking and flotation method to determine its true condition. The discovery of three or more kernels with emergence holes should be a warning to the elevator operator not to buy.

A simple method has been suggested that makes it possible to pick out the damaged kernels in 2 or 3 minutes.<sup>1/</sup> Prepare a 2-percent ferric nitrate solution by adding 2 grams of hydrated ferric nitrate to 100 ml. of water. Pour the 100-gram sample of wheat into a pan containing about 1 pint of this solution, or enough to come about an inch above the sample. Agitate the pan with a swirling motion for 30 seconds to wet the kernels thoroughly. The kernels

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<sup>1/</sup> A. C. Apt. A rapid method of examining wheat samples for infestations. Milling Prod. 17(5): 4. 1952.

with emergence holes will come to the surface, where they can be quickly counted.

A few light kernels with air bubbles clinging to them and a few kernels containing late stages of the grubs may also float. Therefore, before making a final count bob all floating kernels down with the fingers a couple of times. The undamaged kernels will remain down, and those with emergence holes or containing full-grown larvae will float. If the sample contains a lot of chaff, this will also float and must be skimmed off. A few shriveled kernels may also float.

The ferric nitrate solution can be used over and over. After use strain it through cheesecloth and return to the container. One gallon can be prepared for less than 50 cents.

A slower method sometimes used to detect weevil eggs in wheat consists in immersing a sample in an acid fuchsin stain. Grain weevils lay eggs in holes drilled vertically into the kernels and seal them with gelatinous plugs. These plugs are about the size of a pin prick and difficult to see with the unaided eye, but when stained they become cherry red. One or more of them in a kernel indicates the probable presence of a hidden infestation.

To prepare this stain mix 50 cc. of glacial acetic acid in 950 cc. of distilled water and add 0.5 gram of acid fuchsin. After soaking the wheat sample in warm water for 5 minutes, immerse it in the stain for 2 to 5 minutes, and then wash the stained kernels in tap water to remove the excess stain.

## Care of Wheat in Elevator Storage

Control of moisture.--Besides being free from infestation, wheat should be low in moisture and free from damage to the germ. High-moisture wheat is attractive to insects, promotes mold growth, and may induce heating. Elevators that are equipped with driers or have a supply of low-moisture wheat for mixing can afford to take a small quantity of wheat that is slightly above safe moisture levels. Larger quantities will present a difficult problem unless adequate rolling stock is available for forwarding the wheat to terminal elevators.

Storage bins.--Storage bins of good construction are needed for the proper handling and conservation of wheat. Steel or concrete bins that are easily cleaned and are equipped with self-emptying hoppers are best. Wooden crib bins and wooden bins of balloon-frame construction are difficult to keep clean and harbor as many insects as a wooden farm bin.

Hoppers in all bins should be reconstructed, if necessary, to make them self-emptying. Until this construction can be accomplished, the wheat in flat-bottom bins must be manually removed after each emptying.

Once each year before harvesttime crib and balloon-frame bins should be emptied and thoroughly cleaned and sprayed. Crib bins have many ledges that gather dust and wheat. There is no easy way to clean them. The best way is to lower a workman in a sling

and let him brush down the side walls. After a bin has been thoroughly cleaned, apply a residual spray with a power sprayer.

Residual sprays.--Several residual sprays have been found satisfactory for treating wooden bins. Those containing DDT are probably the most effective, but you must be careful to avoid a health hazard. To a DDT wettable powder add enough water to make a 2.5-percent spray. Be sure not to use a stronger spray. A spray containing 2.5 percent of methoxychlor or 0.5 percent of pyrethrins or allethrin is safer, since these insecticides present no health hazard. Apply all these sprays at the rate of 2 gallons per 1,000 square feet.

Chlordane sprays are also effective, but pharmacologists and toxicologists warn that chlordane should not be used where it might contaminate foodstuffs. Therefore, do not use this insecticide until it has been determined whether walls sprayed with it will transmit objectionable amounts to the wheat.

### Good Housekeeping

Good housekeeping practices in the elevator will do much to eliminate insect infestations. Insects are unable to breed and maintain themselves on premises that are kept clean and free of accumulations of waste wheat or milled products. The following program should be carried out regularly:

- 1) Sweep out and remove all dust and accumulations of wheat from gallery and head-house floors, flat space

under the eaves, around edges of bins, structural members, and other flat surfaces near the top of the elevator.

2) Remove all junk--unused machinery, sacking tools, and parts--or store it where dust or waste wheat cannot accumulate. Arrange fire barrels or other equipment so that they will not interfere with cleaning operations.

3) Remove waste wheat and chaff from the parts, tunnels, or lower portions of the elevator.

4) Clean elevator boots, legs, and head, horizontal screw conveyors, and spouting.

5) Remove promptly and dispose of all waste wheat and dust gathered during cleaning operations.

6) Inspect cleaning machinery and dispose of tailovers promptly.

### Supplementary Measures

Fumigation.--To supplement these good-housekeeping methods, fumigate elevator legs and screw conveyors as often as necessary to prevent infestation from being established there. Use carbon tetrachloride mixed with ethylene dichloride (25-75) or with ethylene dichloride and ethylene dibromide (60-35-5). The quantity will vary from 1 1/2 pints in the small boots of country elevators to as much as 1/2 gallon in the boots of the large terminal elevators. Screw conveyors will require about 4 ounces per foot. Dosages can be adjusted to suit conditions in different elevators.

When an elevator is empty, the insect population can be greatly reduced by fumigating the entire elevator. For

this purpose calcium cyanide (25 percent hydrocyanic acid equivalent) has proved useful when applied at 3 pounds per 1,000 cubic feet. Since this material and the gas evolved from it are extremely dangerous, the work should be done by a professional fumigator.

The calcium cyanide should be divided so that proportionate quantities can be thrown into every bin and scattered in the head house and tunnel room or pit. The fumigator must wear a gas mask. If the tunnel room or pit can be sealed off and it is not necessary to go through it on the way out, the calcium cyanide should be applied there first and the room sealed before the bins and head house are treated. To obtain the best results the entire building should be well sealed to hold the gas. Nobody should be allowed to enter the building during the fumigation. (See page 14.)

After an exposure period of 24 to 36 hours, the building should be opened up and well ventilated. Workmen opening the building must wear gas masks. In fact, anyone entering a bin that has been fumigated should wear a gas mask until it is certain that all traces of gas have disappeared.

The residue from calcium cyanide is harmless and need not be cleaned out of the bins.

Spraying. --In warm weather the walls of the tunnels, gallery floor, and head house should be thoroughly sprayed with any of the materials recommended for the treatment of bin walls (see page 8). Spray about three times during the summer.

## Fumigation of Wheat

All wheat that is to be stored for a month or longer should be fumigated within a week after it is received, no matter how clean it may seem to be.

The adult free-living insects are more easily killed than the immature stages living within the kernels. To be sure of destroying these hidden infestations, the dosage must be heavier than has been used in the past.

The efficiency of the fumigant is also dependent upon the wheat temperature; the colder the wheat the more fumigant is required.

Fumigants and dosages.--There are many wheat fumigants on the market. Most of them will give good results if used in the proper manner and in sufficient quantity. A number of representative fumigants and fumigant mixtures, with suggested dosages for use at different temperatures in concrete or steel bins, are given in the table on page 12. Since it is most difficult to obtain a complete kill in the hopper and on the surface, add extra fumigant to the first and last lots of wheat entering the bin. Dosages for wooden bins should be doubled.

Methods of application.--It is important to apply the fumigant rapidly enough to prevent undue loss from evaporation. Apply a liquid fumigant to the wheat stream just as it enters the bin and fill the bin as fast as possible. If applied in a slow-moving conveyor, it would require all day to fumigate a small bin. Apply aliquot quantities in

Dosages of wheat fumigants for use in concrete or steel elevator bins.  
Rate per 1,000 bushels.

Fumigant	80° F. or above	70° to 80° F.	Below 70° F.
Calcium cyanide	10 lb.	10 lb.	15 lb.
Chloropicrin	2	2 1/2	3
Carbon disulfide-carbon tetrachloride (20-80)	2 gal.	2 1/2 gal.	3 gal.
Carbon disulfide-carbon tetrachloride-sulfur dioxide (20-78-2)	2	2 1/2	3
Ethylene dichloride-carbon tetrachloride (75-25)	4	5	6
Carbon tetrachloride-carbon disulfide-ethylene dibromide (76-19-5)	2	2 1/2	3
Carbon tetrachloride-trichloroethylene-benzene-sulfur dioxide (75-10-12-3)	2	2 1/2	3
Carbon tetrachloride-ethylene dichloride-ethylene dibromide (60-35-5)	2	2 1/2	3

the last 100 bushels of each 1,000-bushel draft entering the bin. Do this with a hand or automatic applicator.

If it is not practicable to apply it to the wheat stream, or to transfer the wheat rapidly, apply all the fumigant uniformly over the surface. If the wheat is warm, most liquid fumigants applied to the surface will penetrate to the bottom of a 60-foot bin.

Apply chloropicrin and solid fumigants continuously to the wheat stream with an especially designed applicator as the bin is filled. Apply calcium cyanide, which resembles sea sand, to the wheat stream at almost any point in its journey to the bin--on the belt, in a screw conveyor, or on the up side of an elevator leg. Use it only in closed-top bins with hopper bottoms.

#### How to Treat a Surface Infestation of Moths

Occasionally the Indian meal moth infests elevator bins, but most of the damage is in the top 3 or 4 feet of wheat. Such bins should not be turned, lest new wheat be exposed to attack. It is best to kill the insects and remove the webbing and damaged material before the bin is emptied.

To destroy these infestations, close and seal all bin openings, such as ventilators, manhole covers, and loading chutes, and apply a liquid fumigant as a fine spray to the space above the wheat. The object is to retain the fumigant at the top of the bin rather than have it sink down through the mass of wheat.

Chloropicrin alone or methyl bromide containing 20 percent of either chloropicrin or ethylene dibromide will give good control. Apply with a garden sprayer at the rate of 1/2 to 2 pounds per 1,000 cubic feet of space. The methyl bromide mixtures are obtainable in cylinders and are self-propelled at ordinary temperatures.

## ALL FUMIGANTS DANGEROUS

Any fumigant that is toxic to insects is also toxic to human beings. Therefore, avoid exposure to heavy concentrations of fumigants. Before using a fumigant, the operator should familiarize himself with the recommended method of employing it and with the precautions necessary for its safe application. No one should be allowed to handle a fumigant alone, and all persons handling it should wear gas masks and know how to use them.

Gas masks are available which are equipped with canisters for removing dangerous vapors from the air. A special canister is required for use with each fumigant. Do not take it for granted that any canister will give protection against all gases. Since the life of a canister is limited, it must be replaced whenever it shows signs of weakness. The operator should test the mask for possible leaks before entering concentrations of a fumigant.

An employee should never enter a bin that is being fumigated, either to apply the fumigant or for any other purpose. All fumigants must be applied

from outside the bin. Serious consequences have resulted from workmen unnecessarily entering bins to apply fumigants.

In flat-bottom bins where workmen must shovel out the grain, take special precautions to see that no dangerous concentrations of gas are present when workmen enter the bins, unless they are wearing gas masks.

In many places commercial fumigators, who are familiar with procedures and hazards, are available.

### Regular Inspection of Wheat

Regular inspection of wheat in storage will disclose any infestation that is present. Many elevators turn wheat periodically. This operation consists in moving the wheat from one bin to another, and provides an opportunity for sampling. Some elevators have automatic wheat-sampling devices.

It is commonly believed that a center sample of a deep elevator bin can be taken in a few minutes because the wheat tends to "cone" through the folding in of the surface layer. However, there appears to be no experimental evidence for this belief. When a silo-type bin is emptied, the wheat at the bottom is withdrawn first, and only after about two-thirds of the contents have been withdrawn is there any tendency for the wheat to "cone."

### Use of Low Temperatures

In regions where winter temperatures are low, the elevator operator who has room to turn his wheat can

cool it to a point where insects can do no damage. Stored-grain pests are not active below 50° F. In cold weather wheat can be cooled by transferring it from one bin to another, dropping it through the chilled air or running it over a series of baffles in the process. If the weather is cold enough, this method of treating wheat is one of the cheapest and most effective methods that can be employed. The temperature of the wheat cannot be lowered many degrees by a single turning or transfer, unless the air is considerably colder and the exposure to the cold air is prolonged by slowing down the movement of the wheat.

### Shipping Wheat

Some railway cars are infested with insects that secrete themselves in the woodwork or congregate in accumulations of waste grain and feed behind end and side linings. Before loading wheat for shipment it is good practice to spray the cars with one of the insecticides recommended for treating wooden bins. Spray the floors, side walls, and ends. Spray as far in advance of loading as possible.

Ship only insect-free wheat. The mixing of small lots of infested wheat with clean wheat constitutes an adulteration and is unlawful.

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Prepared by R. T. Cotton and H. H. Walkden, Division of Stored Product Insect Investigations.